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Effects of COVID-19 on Supply Chains

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Abstract: The outbreak of the COVID-19 pandemic had a significant and devastating impact on supply chains worldwide, affecting almost all aspects of human activity. Despite a growing number of articles and research on the subject, there is a notable lack of systematic literature reviews on the effects of the pandemic on supply chains. This study aims to fill this gap by analyzing the available research on the subject and investigating the effects of the pandemic on supply chains. The study employs a systematic literature review, which synthesizes previous literature, articles, and research that have been conducted on the subject. A total of 28 articles were analyzed using the content analysis approach. Results show that 50% of the articles focused on influenza outbreaks, 17.85% were about epidemic/outbreak control, 10.71% were on Ebola and cholera, and only one paper each was dedicated to smallpox, malaria, and coronavirus (COVID-19). The study also encountered some limitations, including the difficulty in finding research materials on the effects of the COVID-19 pandemic on supply chains, as only 28 articles were found to fully meet the research requirements. This is likely due to the fact that the concept of COVID-19 is relatively new, and therefore, there has not been much research done on it yet.

Keywords: COVID-19, Effects of COVID-19, Globalization, Resilience, Supply chain, Disruptions

1 INTRODUCTION

1.1 Background of the Study

A considerable amount of damage has been caused by the COVID-19 pandemic to various industries worldwide, plunging the world into problems of broken supply chains. Adepoju et al.[1] reported that industries and manufacturers in sectors such as the medical and pharmaceutical sectors have and are still experiencing worldwide shortages in essential and non-essential raw materials. The COVID-19 pandemic has resulted in disruptions to the supply and availability of a wide range of raw materials, semi-processed, and finished goods. Despite their robustness and resilience to disruptions, global supply chains (GSCs) have been severely affected by the pandemic, as noted by Zhitao et al.[2]. In response to the pandemic, on March 11th, 2020, the World Health Organization (WHO) declared it a pandemic, and countries around the world were urged to use the Global Strategic Preparedness and Response Plan [3], [4] to prepare and implement response measures. Since the initial outbreak announcement, multiple cases of COVID-19 have been reported in over 200 countries. The disease spread so quickly that by early August of 2020, there were millions of recorded cases of the virus, with reports of over 700 thousand deaths recorded by the World Health Organization (WHO) [5]. The WHO indicated that the outbreak would impact every sector of society, stating that it was more than just a public health crisis, everyone and every sector would be affected [6].

As of the Summer 2020, the number of people who had the virus per 1 million populations given for different regions of the world was as follows: Over 9500 in South and North America, approximately 4000 in Europe, 1,400 in Southeast Asia, over 2000 in the East of the Mediterranean, 750 for the whole of Africa, as well as 180 West of the Pacific region. Total number of globally confirmed cases exceeded 17,000s per population of about 1 million people and 687.64 per population of 1 million people for the recorded corresponding number of deaths [5]. As stated by [7], the Corona Virus is the fifth recorded global epidemic outbreak, after only the influenza virus (H1N1) that broke out in 1918, the 1957 influenza virus (H2N2), 1968 influenza virus (H3N2), as well as the Pandemic flu (H1N1) that was last recorded in 2009, these causedthe deaths of approximately 50 million, 1.5 million, 1 million, and three hundred thousand people respectively.

The COVID-19 pandemic has had far-reaching effects on the global supply chain, causing disruptions that have reverberated through various sectors of the economy. The pandemic's impact was first felt in China, where the delay in the manufacturing of fashion goods triggered a cascade of events that resulted in the closure of shops worldwide. As a result, businesses were forced to cancel product orders, rendering supply chains vulnerable to the pandemic's economic consequences[8].

These disruptions were not limited to China alone. In fact, a study by Amankwah-Amoah et al. [9] found that 94 percent of the top 1000 companies experienced disruptions in their supply chains as a result of the pandemic. These disruptions had social and economic implications, with millions of people around the world losing their jobs as a result of the pandemic's impact on supply chains. Majumdar et al. [10] highlighted that the

clothing supply chain in South Asian countries was particularly hard hit, with several million staff being out of jobs.

The pandemic has had far-reaching effects on the global supply chain, altering supply and demand dynamics worldwide. As lockdown restrictions are lifted, demand is increasing, but it remains uncertain if it will fully return to pre-pandemic levels. Job losses and remote work have impacted global demand and supply, causing both positive and negative effects on supply chains. Businesses and institutions have implemented plans to mitigate COVID-19's impact on their operations, hoping for a temporary rather than permanent outbreak.

1.2 Objectives of the Study

The aim of this research work is to investigate the impact of the COVID-19 pandemic on supply chains. The research objectives are as follows:

- To conduct a systematic review of existing research on the effects of the COVID-19 pandemic on supply chains.
- To analyze and examine the impact of the COVID-19 pandemic on supply chains.
- To provide information on the effects of the COVID-19 pandemic on supply chains.
- To identify potential strategies for managing and mitigating the effects of the COVID-19 pandemic on supply chains.

Since the outbreak of the COVID-19 pandemic in 2020, numerous studies have been conducted on its causes, effects, and related areas. A considerable body of literature has been published on the subject of the COVID-19 pandemic's impact on supply chains in various fields. This study will be a systematic review of relevant literature dating from 2020 onwards, with a focus on the effects of the pandemic on supply chains.

1.3 Research Questions

In order to advance and contribute to the supply chain literature on the impact/effects of the COVID-19 pandemic, this study will examine the following research questions:

1. What are the published research on the COVID19 outbreak with respect to supply chain (SCs)?
2. What are the effects of the COVID19 virus outbreak on global supply chains?
3. What information is available on the effects of the COVID-19 pandemic on supply chains?
4. What strategies can be employed to manage the effects of the COVID-19 pandemic on supply chains

1.4 Significance of the Study

Earlier studies have examined the effects of epidemics and pandemics [11], the effects of past epidemics and pandemics on supply chains [12], and consumer panic-buying behavior during epidemic outbreaks or pandemics [13]. However, this research study will specifically focus on conducting a literature review of studies published on the impact of the COVID-19 outbreak on the supply chain. The results of this study can be useful for researchers, students, and scholars to conduct impactful research on the effects of the COVID-19 outbreak on supply chains. Additionally, policymakers and practitioners can utilize the findings from this research to make informed decisions and address the actual impact of the COVID-19 outbreak on the global supply chain (GSC).

2 LITERATURE REVIEW

This chapter aimed to establish a theoretical framework for the study by reviewing relevant literature and identifying and addressing related research questions.

The impact of the COVID-19 pandemic on supply chains has been the subject of intense research and study by scholars and researchers worldwide. According to Udofia et al. [14], the pandemic triggered disruptions in supply chains, but the productivity of manufacturing firms was not significantly affected. Previous research has also examined factors that affect the supply chain, such as those identified by [15] and [16].

However, research conducted before the COVID-19 outbreak has also identified other threats to supply chain disruptions that are not related to the pandemic. For example, Konecka[17] noted the risk of disruptions such as environmental catastrophes, terrorist activities, globalization, unanticipated alterations in consumer demand, shorter product lifecycles, and a reduction in the number of suppliers.

Every type of supply chain has been critically and significantly affected by the COVID-19 outbreak [18]. The potential economic losses due to pandemics were also discussed by Fan et al. [19], and Barua[20] used a macroeconomic model to illustrate the possible effects of the COVID-19 outbreak. The pandemic has demonstrated that global supply chains can be easily and severely damaged, as highlighted by He et al. [21] in their study on the impact on industries in China.

Furthermore, the COVID-19 pandemic has also impacted the exportation of Indian fruits and vegetables, as noted by Joshi et al. [22]. This pandemic has exposed the fragilities in global supply chains, as discussed by Ivanov and Dolgui [23], and emphasized the importance of the ability to adapt to unexpected challenges in managing supply chains during a pandemic.

There is a wide acceptance and belief that COVID-19 opened an array of unexpected and unprecedented fragilities in global supply chains and as such, in managing SCs during a pandemic of any kind, the abilities and capabilities to adapt to unexpected fragilities cannot be overstated, and should not be underestimated [23].

The COVID-19 pandemic has caused significant disruptions in global supply chains, leading to shortages and delays in the delivery of goods and services. Many authors and researchers have indicated that these disruptions were greater in scope than those experienced locally [24]. Highly globalized industries, such as the automotive and electronics industries, were especially vulnerable to these disruptions, as they rely on complex, international supply chains that were severely impacted by the pandemic[24], [25].

The worldwide production and supply chain disruptions resulting from the pandemic have prompted the introduction of various proposed strategies and solutions aimed at enhancing the resilience and sustainability of the system, as noted by Kumar et al. [26]. One such strategy is diversification of supply chains, which involves sourcing raw materials and intermediate goods from multiple countries. For instance, companies in the fashion industry in the United States of America source their raw materials from various countries to minimize the risk of COVID-19 and increase flexibility [27].

It is important to note that the impact/effects of the COVID-19 pandemic on global supply chains will not only be felt in the near future, but it will also have long-term effects. Industry researchers and practitioners have warned that the pandemic will lead to changes in consumer behavior, shifts in global trade patterns, and disruptions in production and transportation that will affect the industry for years to come [28].

According to research studies, the COVID-19 outbreak has had a significant impact on the global supply chains, causing disruptions in demand and supply, and problems in the transport sector, particularly in the maritime industry. The inelasticity of global supply chains has been tried and proven owing to the extent of these disruptions [29]. However, despite the disruptions, only a small percentage of respondents (6 percent) are in the process of shifting supply chains from China.

The clothing industry is among the sectors that were greatly affected by the COVID-19 outbreak, leading to disruptions in production and supply chains. Milewska [30] highlighted that the COVID-19 outbreak caused a change in the development of e-commerce, resulting in a shift to deliveries to strictly online customers. In addition, there were disruptions in deliveries from countries with low costs of production. However, according to the companies studied, there has been no extensive relocation of garment manufacturing from low-cost nations to Poland, and this is not expected to be a consequence of the COVID-19 outbreak in the long-term.

To manage the impact of the COVID-19 pandemic on the supply chain, Hasin et al. [26] developed strategies such as manufacturing flexibility, diversification of the source of supply, and development of backup suppliers. These strategies were found to yield positive results in managing the effects of COVID-19 in the ready-made garment industry supply chain.

Zhitao Xu et al. [2] also examined the impact of the pandemic on global supply chains (GSCs). They noted that the pandemic affected all stages of the supply chain and causing extensive disruptions in various industries, including electronics, prompting companies to diversify suppliers, increase inventory, and adopt new technologies. The study highlights the importance of enhancing supply chain resilience and adopting novel strategies, such as relocations and back-shoring, to mitigate vulnerabilities during times of crisis. Therefore, understanding the impact of the pandemic on global supply chains is crucial for building more resilient supply chains that can withstand future crises. The findings of this study can assist industrial managers in identifying, classifying, and categorizing the impacts and strategies necessary to handle the significant supply chain disturbances caused by the pandemic, as well as to recover from supply chain disruptions.

2.1 Impacts of COVID-19 Outbreak on Global Supply Chains

Global supply chains (GSCs) have faced sudden damage from various natural disasters in the past, such as the 2011 earthquake in Japan, the 2003 outbreak of SARS in China, and the 2004 tsunami in Indonesia. These disasters happened before the COVID-19 pandemic [31] [32]. These natural disasters were localized and short-lived, and production was restored within weeks after they occurred. But the coronavirus outbreak was different from all previous events in every way. Events like wars, nuclear or radiation accidents, tsunamis, and earthquakes usually affect a specific region for a brief time. But in only four months after it started, the COVID-19 virus had infected the whole world, forcing billions of people to stay at home and shutting down key economic sectors partially or fully. The COVID-19 disease affected supply chains on a much bigger scale both locally and globally, from raw material sourcing to production sectors to final consumers. This showed how businesses are linked through complex GSC networks, where upstream actors are influenced by downstream

decisions that have been directly impacted and have seen major demand changes [33].In this section, we examine the effects of the pandemic on different sectors, including food, medicines and medical devices, high technology products, textiles and apparel, and personal protective equipment (PPE) and ventilators.

2.1.1 Food Global Supply Chain

Global food supply chains were impacted by two significant factors: farming and transportation. As a result of labor shortages and logistical disruptions stemming from the pandemic, India, the world's leading rice exporter, was forced to suspend its exports, while Vietnam, the third-largest exporter of rice, considered reducing its quotas by up to 40% compared to the previous year's corresponding period [34]. Canceled flights, lack of truck operators and drivers, time-consuming inspections, and customs quarantine caused hurdles in the delivery of fresh food [35].

The COVID-19 pandemic's disruption of food supplies was projected to cause a 100% increase in the number of people suffering from severe hunger. In 2019, an estimated 135 million individuals were considered food insecure, according to the Global Reports on Food Crises. As long as the pandemic crisis persists, this number is expected to double [36].

2.1.2 Medicines and Medical Devices

Around 40% of all active pharmaceutical ingredients used globally are reportedly manufactured by Chinese producers [37]. India, the third-largest exporter of medicine worldwide, relies on Chinese sources for over 70% of its drug and medicine production. Consequently, the country faced significant shortages of raw materials when production by Chinese suppliers was halted due to the coronavirus outbreak, which originated in China [38].

2.1.3 High Technology Products

The industry of various high-technology products, such as smartphones, laptops, VR headsets, and other tech gadgets, experienced severe and significant disruptions in their supply chains due to parts shortages caused by COVID-19. One example of this was Apple’s postponement of the deliveries of its newly released products to the global market, which resulted from the closure of Foxconn plants in China amid the pandemic [39]. Similarly, Samsung and LG had to suspend their production activities in South Korea and India. Furthermore, in Europe and US, some production facilities of Airbus, Boeing, and Lockheed were halted, which adversely affected the aeronautic sector.

2.1.4 Textiles and Apparel

The textile and apparel industry was significantly impacted by the COVID-19 pandemic, with both the demand and supply sides affected. Lockdowns, income losses, and reduced social activities led to a sharp decline in consumer spending on clothing and footwear, while factory closures, labor shortages, transport delays, and trade barriers disrupted production [40]. Moreover, the pandemic exposed vulnerabilities and inequalities in the industry's global value chains, with suppliers in developing countries facing liquidity problems, bankruptcy risks, and labor rights violations due to delayed payments or order cancellations by buyers, and workers in low-wage countries suffering from job losses, wage cuts, health risks, and limited social protection [41].

Despite the challenges, the pandemic also accelerated some trends and innovations in the industry. For instance, e-commerce platforms gained more market share as consumers shifted to online shopping, and some brands embraced digital technologies such as 3D design and virtual reality to improve their product development and marketing. Additionally, some manufacturers diversified their product lines to include personal protective equipment (PPE) like masks and gowns [42], [43].

As a result of quarantine measures, retail store closures, loss of income, and fear of spending during the pandemic, consumer demand for textiles and apparel was suppressed. In the European Union, it was predicted that the sector could experience a 50% decline in sales for 2020 [41]. The lack of workers and raw materials shortages and inputs were also contributing factors. According to a survey conducted by the Responsible Business Alliance, 50% of factories and other suppliers were not functioning at full capacity, while 15% of all factories were operating below 50% production [44]–[46].

2.1.5 PPE and Ventilators

The COVID-19 pandemic has resulted in an unprecedented increase in demand for various types of personal protective equipment and medical supplies, such as surgical masks, ventilators, surgical gloves, and coveralls. According to estimates by the World Health Organization (WHO), the monthly requirement of medical masks, examination gloves, and medical goggles are about 89 million, 76 million and 1.6 million

respectively. Moreover, the global demand for new ventilators has substantially surged since the pandemic began. In 2019, the demand for ventilators worldwide was about 77,000, but in 2020, it was estimated to be over 250,000 [3], [47].

3 RESEARCH METHODOLOGY

For this research study, the methodology employed was a systematic literature review (SLR). The aim of an SLR is to collect evidence about a specific topic, adhering to predetermined eligibility criteria, and answering research questions [48]. As pointed out by Tranfield et al. [49], the systematic literature review is a rigorous framework that is well-suited for conducting literature reviews. Although the Cochrane Library [50] notes that this research method has primarily been used in the medical sciences, it has been in use for a long time. The systematic literature review approach is a valuable method that facilitates the organization, synthesis, and identification of emerging paths and opportunities, while also providing a comprehensive understanding of the pertinent issues, discrepancies, and constraints encountered in prior studies on related topics. The Systematic literature review is defined by Petticrew, [51, pp. 99–100] as: "an effective method for testing hypotheses, summarizing the findings of previous and ongoing research, and determining whether previous studies are consistent with one another; These duties are obviously not specific to medicine."

In recent years, researchers such as Mustafa and Irani[52] and Queiroz et al. [53] have utilized the systematic literature review (SLR) approach to investigate issues related to the supply chain. These and other studies conducted using the SLR method demonstrate that it is a systematic and comprehensive approach to conducting literature reviews. While the use of SLR has been used in certain fields [49], the impact of the COVID-19 pandemic on global supply chains is a relatively new and emerging topic with limited literature available on the subject.

As rightly noted by Tranfield et al. [49], in topics that are newly emerging and fields rapidly advancing, papers published in journals can be difficult to find. However, studies that have been recently carried out have applied Systematic literature review (SLR) successfully to themes that are emerging particularly in management. For instance, in understanding procurement and supply chain resilience, putting literatures that were published between 2000 and 2013 into consideration, and pickinging 30 papers for analysis, Pereira et al. [54] applied a Systematic Literature Review (SLR). Tachizawa and Wong (2014) also used the SLR study with a small sample in a new field of research, to propose a framework for multi-tier, sustainable supply chains making use of 39 previous research papers.

The Systematic Literature Review (SLR) has proven to be an effective approach to field development due to its ability to systematically identify areas of the field that require further research, new methods, and new research opportunities [54]. By utilizing SLR, relevant research materials and articles can be thoroughly examined, ensuring that no important information is overlooked and ensuring replicability. Therefore, to comprehensively investigate the effects of the COVID-19 pandemic on supply chains, employing the Systematic Literature Review (SLR) is the most suitable approach. In recent years, there have been several published SLRs on supply chains, such as those conducted by Abidi et al. [55], Fischl et al. [56], Datta[57], Friday et al. [58], Kamal and Irani [52], Tachizawa and Wong [59], Kembro et al. [60], and Pereira et al. [54], underscoring the value and applicability of this approach in the field. This research study has been organized in accordance with the systematic literature review (SLR) framework, which follows the steps established by Tranfield et al. [49] and Denyer and Tranfield[61].

The first stage of this research study (planning the review stage) involves defining the scope of the study, delimiting the subject, and establishing the range of literature [49]. This stage aims to determine what is known and unknown regarding the impact of the COVID-19 pandemic on supply chains. To ensure objectivity and reliability, a research protocol was designed, and the interdisciplinary nature of the subject was taken into account.

The second stage (conducting a review stage) involves searching for relevant materials for the study. Only materials that meet the criteria outlined in the research protocol are considered, in adherence to the recommendations of Tranfield et al. [49]. To ensure internal validity, solely Scopus-indexed journals are included, and the data is collected and analyzed using the MAXQDA software [53], [62]. Furthermore, Bibliometrix is used for science mapping and analysis [63].

The final stage of the systematic literature review is the reporting and dissemination stage, in which the findings from the study and analysis of the literature are presented.

Furthermore, a research agenda featuring open questions and recommendations for both scholars and practitioners has also been made available. In addition, the conclusion provides a concise overview of the managerial and theoretical implications arising from the study. A schematic framework has been presented, detailing the number of papers retrieved at each stage, and reflecting the precise methodology employed throughout this investigation.

Table 1: Research protocol

Research protocol	Details description
Various databases of research:	Science Direct(Elsevier), Informs Pubs Online, Scopus database, Wiley Online Librar, Emeraldinsight, Taylor & Francis, Online, Inderscience, and Springer Link
Publication type:	Only peer-reviewed journals were used
Language:	Papers written in English language were only considered
Date range:	The search range was from 2012-2022
Search fields:	Titles, abstracts, and keywords
Search terms: applied in Titles in Scopus Database	("outbreak*" OR "pandemic*" OR "covid-19*" OR "epidemic*" OR "disease*" AND "humanitarian operati*" OR "humanitarian relief*" OR "suppl* Chain*")
Inclusion criteria:	Included papers are those that presented outbreaks in a logistic/ supply chain context
Exclusion criteria:	Papers that presented outbreak discussion without protagonizing logistics/supply chains and review papers were excluded
Extraction of data and monitoring:	The study utilized MAXQDA, a qualitative data analysis software, and Bibliometrix, a tool within the R software.
Analysis and synthesis of data:	A content analysis approach was performed, supported by the Bibliometrix and MAXQDA

4 DATA PRESENTATION AND DISCUSSION

4.1 Information from the selected papers

In accordance with the previous section, the software application known as Bibliometrix, which utilizes the R-tool, was employed for the purposes of this research study [63], [64]. The R-tool is an open-source application that possesses the capability of extracting data and information from a variety of sources, such as Scopus, Clarivate Analytics' Web of Science, and others. It has been extensively used in various literature reviews to support robust and reliable science mapping [64]–[67]. For this research study, papers meeting the requirements of the research protocol were sought from the year 2012 onward. Following careful consideration of all inclusion criteria and a 10-year time frame, 28 papers were successfully identified.

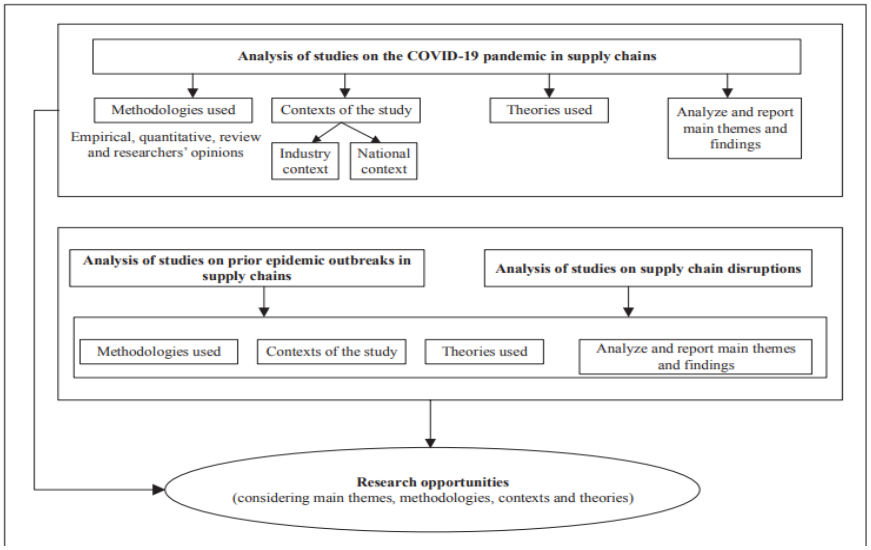

Figure 1: A schematic framework of the analysis process

4.2 Journals publications

Table 4.1 below displays the number of papers published by each journal. The results as seen on the table shows that the highest number of publications are related to production and operations management. Specifically, journals on operations management, operations research, and logistics are prevalent, such as the Journal of Humanitarian Logistics and Supply Chain Management, Transportation Research Part E, and journals on controlling operations or productions.

While this systematic literature review acknowledges the limited number of papers on COVID-19 and epidemic outbreaks, it also identifies the prominence of journals on operations research and operations management. To fill the gap in the literature, more articles and studies on these topics are required. The top

publications in this area are Production and Operations Management, Annals of Operations Research, European Journal of Operational Research, American Journal of Medicine, Humanitarian Logistics and Supply Chain Management, Operations Research, Socio-Economic Planning Sciences, and Transport Research Part E, which account for 60.7% of the total publications. Additionally, the International Journal of Integrated Supply Management, the International Journal of Production Research, and the Transport Research Part E are notable journals that demonstrate a recent interest in production research, logistics, and supply chain.

Table 2: Published articles by the journals

Sources	Articles
Production and Operations Management	3
Annals of Operations Research	2
American Journal of Medicine	2
European Journal of Operational Research	2
Journal of Humanitarian Logistics and Supply Chain Management	2
Operations Research	2
Socio-Economic Planning Sciences	2
Transportation Research Part E	2
Computers and Industrial Engineering	1
Computers and Operations Research	1
Networks and Spatial Economics	1
International Journal of Production Research	1
Journal of the Operational Research Society	1
Influenza and Other Respiratory Viruses	1
Journal of Emergency Management	1
Manufacturing and Service Operations Management	1
International Journal of Integrated Supply Management	1
Management Science	1

4.3 Epidemics and outbreaks categorization in supply chains

In order to ensure that the findings derived from the literature review are reliable, valid, and objective, a content analysis method was employed in accordance with the approach adopted by [68], [69], and [53]. As suggested by prior research [53], [70], the coding-scheme approach was utilized. The content analysis was conducted using four categories, namely Outbreak/Disease reported, Purpose, Main method/Theoretical approach, and Supply chain/Logistics/Operations implications. This approach was chosen to synthesize the key findings of the study obtained from the literature review.

Table 3: Categorization of Contents analyzed

References	Outbreak /disease reported	Purpose	Main method/ Theoretical approach	Supply chain/Logistics/ Operations implications
[71]	Influenza	Examine the inefficiencies in vaccine allocation and assess the proposed contractual mechanism model for supply chains.	Non-cooperative game with incomplete information/Game theory/Supply chain coordination/Performance analysis.	The inadequacy or excess of vaccines within a synchronized and integrated global supply chain may result in supply chain costs. Consequently, the use of a coordinated contractual mechanism has the potential to produce benefits, such as minimizing costs and avoiding shortages.
[72]	Influenza	To analyse the infrastructure and logistics protocols implemented in airports to facilitate the dispensation of medication.	Secondary data analysis (WHO)	The logistics infrastructure is a critical component in mitigating the spread of epidemics, but it also presents significant challenges. Furthermore, the safe handling of medications requires stringent control measures.
[73]	Epidemic /outbreak control	To develop a model that can enhance the provision of vaccines through the procurement process, while also minimizing social costs.	SIR epidemic model/Option contract/Procurement planning/Simulation experiments.	The utilization of an option contract model offers the potential to aid suppliers in establishing the maximum value of vaccines that are demanded, while also taking into account the buyer's forecasting needs. This approach can lead to a reduction in the minimum procurement necessary and associated social costs.

[74]	Influenza	Designing a logistical framework for the allocation of medical resources that accounts for the diverse actors involved in the supply chain.	Operations Research and Dynamic Programming	A demand-based approach model has been incorporated that considers plans, orders, shipping, and resource allocation in developing a logistics model for medical resource allocation. As a result, a substantial reduction in forecast error was observed, indicating enhancements in the supply chains.
[75]	Ebola	Conducting an analysis on the dissemination of Ebola via travelers, and evaluating the crucial role that airport infrastructure plays in mitigating the spread of the virus.	Mathematical Modeling and Statistical Analysis	The implementation of passenger screening at the airport of origin has been identified as a potentially effective measure to prevent the spread of Ebola by travelers. Nonetheless, it should be noted that the logistics infrastructure at the airport could pose a significant constraint to its implementation.
[76]	Cholera	The authors propose a two-model approach for the response of humanitarian supply chains, taking into account factors such as distance, congestion, and individual decisions related to facility location and supply/service provision.	Centralized planner's model/Beneficiary decision model/Secondary data /Player-facility specifc congestion weights problem / Network congestion games	The authors suggest that the proposed models may prove advantageous for post-disaster response efforts by supporting public health SCs, particularly in allocating resources. The models demonstrate how vital it is to account for individual behavior's effects on humanitarian SCs to achieve network optimality.
[77]	Smallpox	The proposed model aims to address emergency response to smallpox through supply chain management, with a particular focus on vaccination in a large-scale scenario.	Numerical experiment/Linear programming	The design and operational procedures of emergency network response have a direct impact on outbreak containment, as well as on social and economic activities. To address this, a two-stage model was developed for responding to smallpox through the emergency supply chain. The model accounts for pandemic progress in the first stage, followed by the distribution process in the second stage. The authors emphasize the importance of available resources in effectively controlling epidemics.
[78]	Malaria	The authors introduced an approach for drug distribution in a health system with three tiers, which takes into account both strategic and tactical factors.	Stochastic programming/Case study /Markov decision /Cluster	The models demonstrate that an effective transportation plan can significantly mitigate the costs and shortages associated with drug distribution. Nevertheless, implementation is impeded by several challenges, including inadequate communication, insufficient government engagement, and a deficient logistics infrastructure.
[79]	Coronavirus (COVID-19)	Investigation of the resilience of SC in a COVID-19 disruption scenario	Simulation	The COVID-19 outbreak has resulted in a multitude of disruptions across various supply chains. Despite the extent of these impacts remaining unclear, the authors of this paper offer significant and distinctive perspectives on how to mitigate the risks associated with COVID-19 and enhance resilience against its outbreak. They emphasize the importance of establishing agile, adaptable, and responsive supply chains that can facilitate the redistribution of demand and supply in real-time.
[80]	Influenza	Conduct an analysis of the supply chain distribution of chickens and the impact it may have on the propagation of the H7N9 avian influenza virus.	Secondary data	There is a need for retailers and suppliers to develop a more integrated approach to their work, and this can be facilitated by leveraging the capabilities of modern technology. In addition, all members of the supply chain, including governments, can take steps to enhance the traceability of goods.
[81]	Epidemic /outbreak control	The authors proposed the development of a model for distribution networks that incorporates the influence of the latent period on demand during an epidemic.	Genetic algorithm/Multi-objective stochastic programming model/Numerical example model/Optimization/ Monte Carlo simulation/SEIR epidemic diffusion	When developing effective solutions for the distribution of emergency medicine, the presence of latent periods can present significant constraints, resulting in delays and uncertainties. To overcome these challenges, a viable strategy to consider is the allocation of materials through collaborative and integrated efforts across multiple areas.
[82]	Influenza	This paper discusses the planning, production, and distribution of vaccines within the supply chain, and the related challenges that arise.	Conceptual	Active participation of policymakers throughout the entire supply chain is essential to effectively combat the pandemic and establish logistics capabilities at all stages, from planning to development. It is recommended that all members of the Operations and Supply Chain Management (OSCM) community adopt an integrated approach with their respective governments.

[83]	Influenza	This paper aims to provide an analysis of the logistics and supply chain management lessons learned from the Influenza pandemic. Specifically, it focuses on the production, distribution, and management of vaccines in response to the outbreak.	Conceptual	The effective functioning of logistics and supply chains plays a pivotal role in advancing public health. It is imperative that policymakers take full responsibility for these activities to prevent scarcities.
[84]	Influenza	This paper proposes an optimized model for the dynamics of vaccine supply chain, with a focus on the relationship between contractual actors involved in the process.	Game theory/ Optimization	The lack of coordination and collaboration among actors in the vaccine supply chain can lead to underestimation of the system's capacity and result in shortages. The authors suggest that while achieving a global social optimum can be challenging, a feasible approach to attain the most favorable societal results may involve a contractual agreement founded on the principles of cost-sharing between vaccine manufacturers and the government.
[85]	Influenza	To document the logistics difficulties in addressing public health emergencies, with due regard to international collaboration and assistance for responding to the outbreak.	Case study	The crucial role of logistics activities in providing effective interventions for epidemic/outbreak control cannot be overstated. While logistics can enhance the quality of the response, international cooperation in logistics plays an even more pivotal role in this regard.
[86]	Ebola	The objective is to create a two-level system that can efficiently allocate treatment units in different regions and explore four programming strategies for managing these units in affected localities.	Heuristic/ Dynamic approximate programming algorithm /Myopic linear programming/Estimation–optimization	In this context, the authors propose a recommended course of action for allocating resources which entails a forward-looking strategy that anticipates probable future cases. By leveraging empirical evidence and data-driven insights, this approach offers a dynamic and attractive means of allocating resources.
[87]	Influenza	Proposal of a model for distributing vaccines considering the minimizing the vaccines needed to control the pandemic and equity criteria to cover subgroups	Mathematical programming/Discretization with multiparametric disaggregation	The proposed model can serve as a valuable tool for public health policymakers in formulating logistics plans for vaccine storage in order to contain outbreaks. The policies for allocating vaccines have a direct impact on the efficiency of resource allocation. Furthermore, implementing policies for ensuring equitable vaccination coverage can significantly improve the efforts to eliminate outbreaks.
[88]	Epidemic /outbreak control	There is a current endeavor underway to establish a model for distributing vaccines that can offer an intermediate solution that is deemed optimal.	Simulation/Stochastic-SIR model	Given the significant constraints of logistics resources, the utilization of the available resources can lead to an intermediate solution that can be considered as the most optimal.
[89]	Influenza	The development of optimization systems geared towards the allocation of patients and resources is being pursued.	Case study /Optimization models	The proposed models have the potential to assist healthcare systems in logistics and supply chain management to effectively plan and allocate resources. Additionally, these models can aid decision-makers in mitigating resource scarcity.
[7]	Influenza	A proposition for a framework to manage the logistics of an epidemic outbreak, specifically for the containment of H1N1, is presented. This proposal draws inspiration from the previously established model introduced by Buyuktahtakın et al. in 2019.	Case study /Mixed-integer non-linear programming model	The proposed model was compared with the one suggested by Buyuktahtakın et al. (2019) and both were found to have similarities and differences. The model aids in making decisions related to the duration for which the unutilized wards should be kept open or closed during the management of epidemics.
[90]	Cholera	A data-driven model is proposed to support policies for controlling epidemics and emergency health response systems. The model is based on a dataset and aims to enhance the decision-making process in response to epidemic outbreaks.	Secondary data analysis /Integer linear programming	The utilization of data-driven analysis facilitates the development of robust supply chain models which allocates resources and respond to emergency situations. Such models strengthen the integration and coordination of healthcare staff in the supply chain.

[91]	Ebola	Proposal of an epidemic model of logistics to control the Ebola epidemic, taking into account where the resource is located	Mixed-integer programming model/Secondary data (WHO)/Case study	This study introduces and validates an optimized model for epidemic logistics, which can be used for resource allocation in healthcare supply chains. The proposed model takes into account the complexities associated with treatment centers, as well as geographical parameters and the varying dynamics of infected individuals in various regions. By considering these factors, the model provides essential information that can inform decision-making and resource allocation strategies for effective epidemic control.
[11]	Influenza	There is a proposal for a scheduling model to determine the optimal allocation of resources.	Case study/Simple deterministic SIR model	Managing scarce resources while considering the needs of multiple stakeholders is a complex undertaking. However, a deterministic model can aid in devising effective strategies and policies for the management of limited resources.
[92]	Influenza	A model is proposed that takes into account dynamic strategies for drug distribution.	Simulation/Optimization model	The proposed model is designed to dynamically redistribute drugs and medical supplies, accounting for the progression of the outbreak. This approach takes into consideration various logistics factors, such as costs, distance, and resource availability, alongside the evolving pandemic situation.
[93]	Epidemic /outbreak control	The proposition of policies for the mitigation of epidemic impacts while accounting for significant uncertainties.	Exploratory modeling and analysis methodology/Supply shortage model / Machine learning/Scenario discovery	The control of epidemics relies heavily on the healthcare supply chain, which ensures a smooth and timely flow of drugs and medical supplies, thus reducing shortages. As such, the duration and severity of an epidemic can be significantly influenced by the effectiveness of supply chain activities, particularly in relation to resource allocation.
[94]	Cholera	A novel Haddon Matrix is proposed to facilitate the response to epidemics.	Literature review/Haddon Matrix	This proposed framework offers valuable insights into the humanitarian logistics operations that occur during all phases of a crisis event, including pre-event, response, and post-event activities.

Table 4: Applying a content analysis method to examine the papers

Reported epidemic/outbreak	Numberof papers	Percentage (%)
Influenza	14	50
Epidemic/outbreak control	5	17.85
Ebola	3	10.71
Cholera	3	10.71
Smallpox	1	3.57
Malaria	1	3.57
Coronavirus (COVID-19)	1	3.57
Total	28	100

5 FINDINGS AND DISCUSSION

Through content analysis, it was determined that the majority of the selected papers focused on influenza outbreaks (50%), while others covered epidemic/outbreak control without a specific outbreak (17.85%). Ebola and cholera each represented 10.71% of the papers, with smallpox, malaria, and coronavirus (COVID-19) accounting for the remainder, with only one paper dedicated to these topics. In terms of methodology, the preponderance of the papers employed optimization models using various mathematical models and approaches, such as game theory, case study and SIR mode, case study and simulation, and mixed integer programming.

Recent academic research conducted by Govind et al. [95] and Ivanov [24] demonstrated the severe impacts of COVID-19 pandemic on global supply chains, but also highlighted the favorable impact of the resulting disruptions on supply chain responses when they occurred simultaneously. As a result, decision and policymakers in supply chains are now better equipped with the technical expertise needed to predict and manage future effects of epidemics and pandemics on their organization's supply chain. Analytical techniques and technologies, such as logistics operation decision-making support and social media analytics, are now available to minimize the impact of future epidemic outbreaks on supply chains. is more contingent on the degree and timing of the diffusion of the disruption, rather than the scope of the upstream disruption itself [96], [97].

6 CONCLUSION

The outbreak of the COVID-19 pandemic has demonstrated the potential for epidemics and pandemics to severely disrupt global supply chains. This study presents a methodical examination of the effects of epidemics and pandemics on supply chains, drawing upon a comprehensive review of pertinent literature including previously published articles, papers, and publications.

The findings of this study reveal that the relationship between supply chain and epidemic outbreaks has primarily centered on the issue of resource allocation and medical supply distribution. Although most of the research has been focused on the influenza epidemic, various other epidemic outbreaks have been documented in relation to the subject of supply chain. However, limitations were encountered during this research, such as the query used for searching the databases, which prevented the assessment of other supply chain related themes, subjects, and articles for review. Another limitation was the difficulty in finding research materials on the effects of the COVID-19 pandemic on supply chains, as only 28 articles met the research requirements. This is likely due to the novelty of the COVID-19 concept and the relatively recent nature of the pandemic.

It is therefore important to encourage and conduct further research on the impact of the COVID-19 pandemic, as well as other pandemics and epidemics, on global supply chains. This will enable the availability of more research materials for future research references and comparative studies. Additionally, it is important to examine other issues related to supply chain management during epidemics and pandemics. For example, there may be a need to explore how supply chains can be made more resilient to cope with sudden disruptions caused by epidemics and pandemics. This could include examining the use of new technologies and more efficient supply chain management strategies.

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